INTED 2010

International Technology, Education and Development Conference

Valencia (Spain)
8th-10th of March, 2010

CONFERENCE PROCEEDINGS

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WELCOME INTRODUCTION

Dear INTED2010 participants,

It is a great honour to welcome you to this forth annual edition of INTED2010 (International Technology, Education and Development Conference).

The main aim of this conference is to provide an international forum, counting with experts in different fields and disciplines from more than 60 countries who will present and discuss the latest innovations in education, technology and development.

With the presence of more than 400 attendants, INTED2010 also aims to be a social platform and a great opportunity for networking, which makes this experience more interesting for its international and multicultural atmosphere.

Valencia, venue of this conference, will provide you with the opportunity to discover a city with impressive architecture, interesting museums, lovely beaches and a varied cultural offer that will make your stay unforgettable.

Thank you very much for coming to INTED2010 and for contributing to the improvement of Education with your projects and experiences. We wish you a fruitful conference!

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CONFERENCE SESSIONS

ORAL SESSIONS, 8th March 2010.

e-learning & Blended Learning (1)
Educational Software and Serious Games (1)
University-Industry Collaboration
Curriculum Design in Engineering Education
Architecture & Urban Planning: Pedagogical & Didactical Innovations
e-learning & Blended Learning (2)
Educational Software and Serious Games (2)
Enhancing Learning and the Undergraduate Experience (1)
Engineering Education: Pedagogical & Didactical Innovations
Architecture & Urban Planning: International Projects & Research
Pedagogical & Didactical Innovations (1)
Computer Supported Collaborative Work. Web 2.0 and Social Networking
Enhancing Learning and the Undergraduate Experience (2)
Experiences in Engineering Education
Arts & Humanities: New Experiences and Pedagogical & Didactical Innovations
Pedagogical & Didactical Innovations (2)
Computer Supported Collaborative Work
Quality Assurance in Education
Learning Experiences in Primary and Secondary School
Bus. Adm. & Mgmt.: Experiences in Education and Pedagogical & Didactical Innovations

POSTER SESSIONS, 8th March 2010.

Poster Session1. Technological Issues & Computer Supported Collaborative Work
Poster Session2. Educational Software and Serious Games & Pedagogical & Didactical Innovations

ORAL SESSIONS, 9th March 2010.

Technology-Enhanced Learning (1)
Curriculum Design and Innovation
Foreign Languages: Experiences in Education
Experiences in Education. New projects and innovations (1)
Teacher and Pre-service Teacher Education Experiences
Experiences in Education. New projects and innovations (2)
Technology-Enhanced Learning (2)
International Projects
Curriculum Design and Innovation. Strategies, Principles and Challenges
Foreign Languages: Pedagogical & Didactical Innovations
Experiences in Education
Technological Issues in Education
Barriers to Learning & Diversity Issues in Education
New Experiences for Curriculum Design
Health Sciences: Experiences and Pedagogical & Didactical Innovations
New Trends in the Higher Education Area
Research on Technology in Education
General Issues. Education and Globalization
Research in Education
General Issues. Education & Development

POSTER SESSIONS, 9th March 2010.

Poster Session1. Experiences in Education and Research & International Projects
Poster Session2. Curriculum Design, University-Industry Collaboration, Quality Assurance & Higher Education Area

VIRTUAL SESSIONS

Computer Supported Collaborative Work
Curriculum Design and Innovation
E-content Management and Development
Educational Software and Serious Games
Experiences in Education
Experiences in Education. Competence Evaluation
Experiences in Education. Enhancing learning and the undergraduate experience
Experiences in Education. Learning Experiences in Primary and Secondary School
Experiences in Education. New projects and innovations
General Issues. Barriers to Learning
General Issues. Education, Globalization and Developmnet
General Issues. Organizational, legal and financial issues
International Projects
New Trends in the Higher Education Area. ETCS experiences and Joint degrees programmes
New Trends in the Higher Education Area. New challenges for the Higher Education Area
Pedagogical & Didactical Innovations. Collaborative and Problem-based Learning
Pedagogical & Didactical Innovations. Evaluation and Assessment of Student Learning
Pedagogical & Didactical Innovations. Learning and Teaching Methodologies
Quality assurance in Education
Research in Education. Academic Research Projects
Research in Education. Experiences in Research in Education
Research in Education. Research on Technology in Education
Technological Issues in Education. E-learning and Blended Learning
Technological Issues in Education. Technology-Enhanced Learning
University-Industry Collaboration
Virtual Universities. Distance education

ABOUT INTED2010 Proceedings CD

HTML Interface: Navigating with the Web browser

This CD includes all presented papers at INTED 2010 conference. It has been formatted similarly to the conference Web site in order to keep a familiar environment and to provide access to the papers trough your default Web browser (open the file named "INTED2010.html").

An Author Index, a Session Index, and the Technical Program are included in HTML format on this disk to aid you in finding particular conference papers. Using these HTML files as a starting point, you can access other useful information relating to the conference.

The links in the Session List jump to the corresponding location in the Technical Program. The links in the Technical Program and the Author Index open the individual paper in a new window. These links are located on the titles of the papers and the Technical Program or Author Index window remains open.

Full Text Search: Searching INTED2010 index file of cataloged PDFs

If you have Adobe Acrobat Reader version 6 or later (www.adobe.com), you can perform a full-text search for terms found in INTED2010 proceedings papers.

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This PDF file is attached to an Adobe PDF index that allows text search in all PDF papers by using the Acrobat search tool (not the same as the find tool). The full-text index is an alphabetized list of all the words used in the collection of conference papers. Searching an index is much faster than searching all the text in the documents.

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3. Type the search text, click Search button, and then proceed with your query.

For Acrobat 9:

1. In the "Edit" menu, choose "Search". You may receive a message from Acrobat asking if it is safe to load the Catalog Index. Click "Load".
2. A new window will appear with search options. Enter your search terms and proceed with your search as usual.

For Acrobat 8:

1. Open the Search window, type the words you want to find, and then click Use Advanced Search Options (near the bottom of the window).
2. For Look In, choose Select Index.
3. In the Index Selection dialog box, select an index, if the one you want to search is available, or click Add and then locate and select the index to be searched, and click Open. Repeat as needed until all the indexes you want to search are selected.
4. Click OK to close the Index Selection dialog box, and then choose Currently Selected Indexes on the Look In pop-up menu.
5. Proceed with your search as usual, selecting other options you want to apply, and click Search.

For Acrobat 7 and earlier:

1. In the "Edit" menu, choose "Full Text Search".
2. A new window will appear with search options. Enter your search terms and proceed with your search as usual.

DESIGN AND DEVELOPMENT OF A SET OF PRACTICAL SESSIONS IN A ROBOTICS AND COMPUTER VISION SUBJECT

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Abstract

This paper presents the process we have followed during the design and the development of the practical sessions in a robotics and computer vision subject. The main goals of the subject are to analyse the kinematics and dynamics of serial manipulators and mobile robots, to study several techniques to extract the most relevant information from the images and to describe how the movement of a robot can be controlled through the visual information extracted from a camera the robot carries on it. With these objectives we have designed a set of practical sessions so that students can reach the objectives of the subject in a very flexible way. We have made use of a software tool we have implemented with the contents of the subject. This tool simplifies the use of the data collected by the robot and the implementation of the necessary algorithms, and it allows the student to develop the practical sessions in his house, with a flexible timetable.

Keywords - Computer vision, mobile robots, educational software, higher education, practical sessions design.

1 INTRODUCTION: MAP CREATION AND LOCALIZATION IN MOBILE ROBOTICS

Nowadays, both computer vision and robotics constitute two fields in Engineering that are in a continuous development and that permit solving with robustness the automation of some tasks in real environments. Thanks to computer vision, we may have a complete description from an environment of from an object. It allows us to carry out processes of object recognition or classification, visual inspection, quality assessment and visual place recognition among other applications.

On the other hand, the presence of robots in our day to day life is continuously increasing both in our houses and in our factories. These robots have moved into such environments to solve our needs in unpleasant or repetitive tasks. However, it is necessary they have a good level of autonomy and robustness. When a mobile robot has to carry out a task in an environment, it needs some mechanisms to compute its localization and the most efficient way to arrive to the target points. In this kind of applications we must take into account that in the real working environments, the robot has to manage with some typical situations such as changes in the environment lighting, occlusions, people movement and changes in the position of some objects in the scene. The representation of the environment must cope with these features so that the robot is absolutely autonomous [1].

This representation (namely map) of the environment can be built using some images captured by the robot along the environment. Taking as a base these images, the most relevant information can be extracted, and from this information, the map can be built [2].

In the Industrial Engineering studies, in the Miguel Hernandez University, there is an optional subject where these topics are studied. Students learn the basic computer vision and robotics concepts and the relationship between them. The main goals of the subject are to analyse the kinematics and dynamics of serial manipulators and mobile robots, to study several techniques to extract the most relevant information from the images and to describe how the movement of a robot can be controlled through the visual information extracted from a camera the robot carries on it.

The practical sessions of this subject allow the students to put into practice the theoretical concepts studied in the classroom. Traditionally, these practical sessions have been developed in the robotics laboratory. The students are proposed some tasks they have to solve making use of a robot and the visual information it captures with a camera it carries on it. The students have to implement the necessary programs to solve them. The main problem of these sessions is the fact that the number of robots and cameras available in the laboratory to develop and test the algorithms is limited and so the available time in the laboratory.

Our objective is to overcome these difficulties and also, to make an adaptation to the new philosophy of the European Space for Higher Education, that must be centred in the learning and autonomy of the student; it should be a less rigid system with regards to the lectures and timetables. With this aim, we are encouraged to use some new methodologies to improve the autonomy of the students.

We have designed and implemented a software tool that facilitates the students to reach the objectives of the subject. This software constitutes a link between the data collected by the real robots and the task the student has to carry out. This way, after an initial presence practical session, where the teacher exposes the fundamentals of the robots and the cameras, the student can develop the rest of the sessions in his house, with a flexible timetable, making use of the software we have designed. When any problem or doubt arises, students can get in touch with the lecturer through a virtual tutoring system.

The remainder of the paper is structured as follows; section 2 presents the principles of design of the software platform and the basic utilities it offers the students. In section 3, we detail the practical sessions we propose the students to develop with the tool. At last, in section 4, we present the conclusions of the work.

2 DESCRIPTION OF THE TOOL DEVELOPED FOR THE PRACTICAL SESSIONS

In this section, a brief description of the utilities and operation of the tool is given. The general philosophy while designing this tool was the simplicity of use, trying to guide the student during all the processes and also taking into account the user is not an expert in this field and everything has to be intuitive so that is has a real pedagogical value.

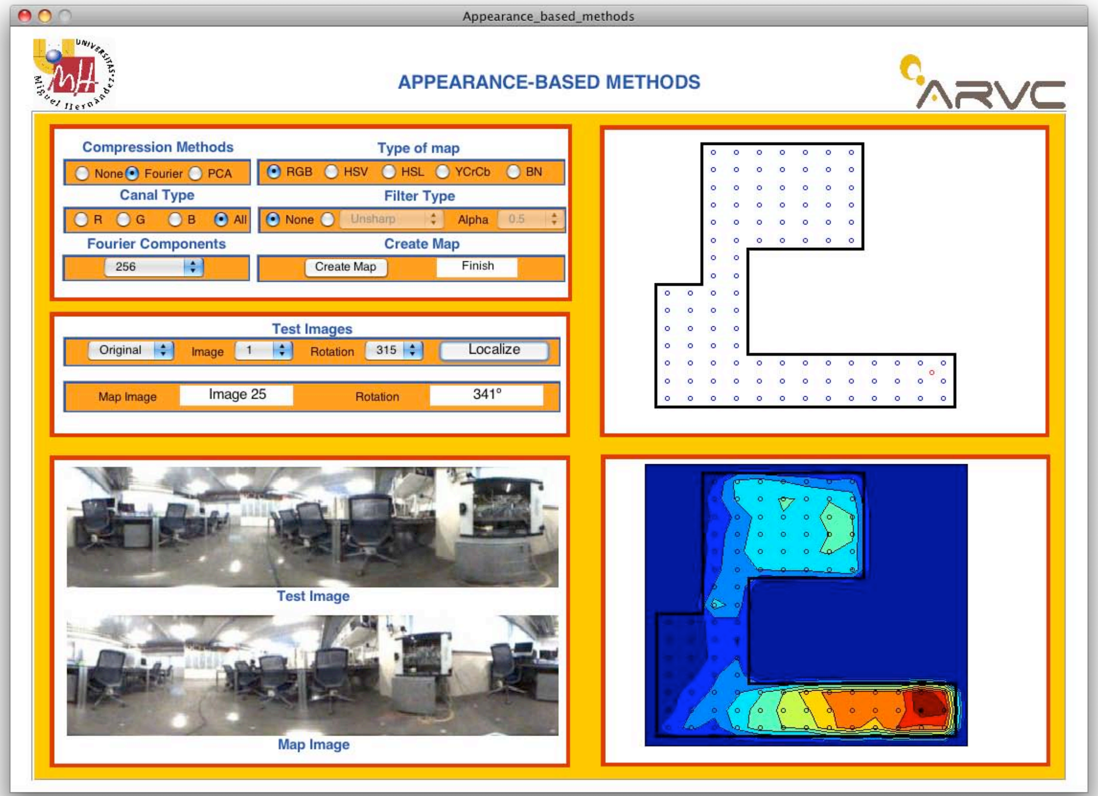

Figure 1. Graphical interface that guides the student through the process

The application has been developed using MATLAB [3]. When the student runs it, a graphical interface appears where the student can carry out all the necessary operations. Fig. 1 shows this graphical interface during an experiment. In broad outlines, this figure shows all the necessary options to create a map and to perform a localization process in an interactive way. A deep description of this tool can be found in [4].

The application contains several databases with panoramic images (these are the training images), which have been captured by a robot on a pre-defined 40x40 cm grid in a laboratory. This grid is show in the right upper side on fig. 1. Also, the application contains several test images that have been taken in half-way points of this grid. There are several sets of test images, depending on the time of the day and artificial lighting available when capture was carried out. Using these images, the student can perform different experiments applying the theoretical concepts, such as:

- Extraction of the most relevant information from the training images. This process is useful when creating a map of the environment, and helps reducing the amount of memory and the computational cost of the processes. This task requires some computer vision concepts as colour spaces, filtering methods and compression methods [5].
- Calculation of the localization of the robot. Using the test images and the different compression methods, the student must be able to compute similarity between each test image and the training images and so, to deduct the position the robot had when capturing the test images. A very interesting point in this task consists in comparing the compression methods against changes in the rotation of the robot and against changes in the environment.
- Study of the main filtering methods to avoid lighting variance. Thanks to this tool, the student can graphically see the effect of the different filters and their behaviour when used to avoid illumination changes.
- Computation of the orientation of the robot. Some methods allow us to compute the orientation of the robot, besides its position. The student has to test them to discover which are the correct methods and the accuracy of the results.

The tool developed includes all the necessary options so that the student can carry out these tasks, in a very intuitive way, centring their efforts in the contents of the subject (not in the implementation details of the algorithms). In the following section we detail the practical sessions we have designed to cover these tasks.

3 PRACTICAL SESSIONS PROPOSED TO THE STUDENTS

In this section, we present the set of practical sessions we have developed to achieve the objectives of the subject.

3.1 Building a map

In this practical session, the student must use the images of the database to build an efficient map of the environment. This map should contain enough information so that the robot can compute its localization and orientation in it and should have an optimal size so that the precision in the localization is reasonable with a low computational cost. The total amount of images is 101.

The student must focus in two main points: the colour codification of the images and the compression to apply.

A. Colour codification

The student can choose between the following five choices [6], [7]:

- Original RGB (Red, Green and Blue) colour map images. This colour model decomposes the image in its primary spectral components of red, green and blue.
- HSV (Hue, Saturation and Value) colour map. Hue is a colour attribute that describes a pure colour, saturation gives a measure of the degree to which a pure colour is diluted by white light and Value represents the brightness of the colour.
- HSL (Hue, Saturation and Lightness) colour map.

- YCrCb colour model (Luminance component and Blue-difference and Red-difference chroma components).
- Gray-level image. This is the only model to use when the images have been captured in grey-level.

In fig. from 2 to 5 we show some colour images and the three-channel decomposition of the proposed colour spaces as they appear in our tool. This is a good mechanism so that student can understand colour spaces and their applications.

(a) (b)

Figure 2. (a) original colour image and (b) R, G and B components.

(a) (b)

Figure 3. (a) original colour image and (b) Hue, Saturation and Value components.

(a) (b)

Figure 4. (a) original colour image and (b) Hue, Saturation and Lightness components.

(a) (b)

Figure 5. (a) original colour image and (b) Luminance component and Blue-difference and Red-difference chroma components.

When building the map, the student can choose to use the information from the three channels or only one of them. After some localization experiments, the student must deduct which is the best colour codification in robot localization processes and if the information of only one channel may be enough to carry out this task. The performance of the maps created will be tested in the following practical sessions (localization of a robot).

B. Compressing methods

To extract the most relevant information from the images, two methods have been implemented in the tool:

- Fourier compression. The Fourier signature of each image is extracted. In this case, the most relevant information of each image is concentrated in the first components of each row. The student can decide how many columns of each Fourier signature are retained. The database is composed actually of the Fourier signature of each image [8].
- PCA compression. The images are compressed using the Principal Components Analysis approach. Each image is transformed to a data vector with the most relevant information on the image. In this case, the student can choose the number of eigenvectors to work with. The dimension of the projection of the images and so, the amount of the information retained during the compression depends on the number of eigenvector chosen. The database consists of the projection of each image and the matrix to make the change of basis [9], [10].

As a third option, the student may decide not to compress the information and to work with all the pixels the original images have.

As a result from this session, the student must be able to make a graphical representation of the amount of memory needed to store the map depending on the degree of compression of the images, and the time elapsed to build the map. These maps will be stored to test their accuracy in robot localization in the following sessions.

3.2 Localization of a robot

In this practical session, the student has to test the maps he has build in the previous session to know its utility and accuracy for robot localization. The student must make use of the test images. When the student selects one of the test images, the position where it was captured is sown as a red point on the bird eye's view of the environment. Also, the student can select the rotation of this image before performing localization. This is the rotation the robot had when capturing the image and, thanks to this option, the student can test which of the compression methods is robust to changes in the orientation. Once all these parameters have been selected, the student can press the button 'Localize'. Once the process finishes, the interface shows the nearest image in the map, and the orientation computed for the test image, with respect to that nearest image. The application also shows the original test image and the corresponding one in the map and a gradient graphic of distances. All this information is shown on fig. 1.

3.3 Image filtering for localization in variable environments

When a robot has to compute its location from visual information in a realistic environment, it has to cope with some usual problems. One of the most important is lighting variation. Depending of the level of artificial illumination, the state of the windows and doors and the time of the day comparing to the time when the training images were captured, the visual information may change greatly and it must be taken into account when comparing the image captured by the robot with those stored in the database. It is therefore necessary to implement a mechanism that allows us to work independently of the lighting conditions of the environment.

To avoid the influence of illumination changes, we can use some kinds of filters on images. This tool includes a wide variety of filters so that the student can test their performance in real situations. The filters he can choose from a list are: unsharp, Prewitt, Sobel, Laplacian of Gradient (LoG), Gaussian, Wiener, average, Laplacian and homomorphic.

In this practical session, we separate the different methods in two fields. The first one is related to the application of a bank of gradient (first derivative) or Laplacian (second derivative) filters. The second one consists in performing a homomorfic filtering of the image, separating the luminance from the reflectance component.

A. Gradient-based filters

This family of methods consists in getting a representation of the image edges. The main advantage of using a representation of the image edges resides mainly in the fact that we obtain a compact representation and that, in most cases, it is insensitive to changes in the lighting on the objects of the image.

The unsharp filtering tries to enhance the overall sharpness of a digital image, by removing low-frequency spatial information from the original image. The resulting image is the subtraction of an unsharp mask from the original image. An unsharp mask is a blurred image that is produced by spatially filtering the original image with a Gaussian low-pass filter. This filter can be considered as a convolution with a two-dimensional Gaussian function, whose parameters are configurable in our tool by the student. Fig. 6(b) shows an example of unsharp filtering (the original image is fig. 6(a)).

Other edge detection filtering can be carried out through the Prewitt gradient filter, based on the estimation of the modulus of the gradient using two masks of size 3x3 (h_1 in the x-axis and h_2 in the y-axis):

$$h_1 = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \qquad h_2 = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

An evolution of the Prewitt Filter is the Sobel filter that, apart from estimating the value of the modulus of the gradient, produces a smoothing of the image that may be beneficial, taking into account the noisy behaviour that the estimations based on the derivation of the image may present:

$$h_1 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \qquad h_2 = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Another method for detecting edges is the Laplacian of Gaussian (LoG) operator, which combines the effect of a Gaussian smoothing with the improvement in the location of the edge (cross of 0 for the second derivative). In this case it is only necessary to apply a mask:

$$h_1 = \begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$$

Fig 6(c), (d) and (e) show an example of images filtered using the Prewitt, Sobel and LoG filters as they are shown to the student in the tool. This has a very interesting pedagogical value as it shows the effects of the filtering so that the student can evaluate its advantages when lighting changes.

B. Homomorphic filters

The Homomorphic filter can separate the components of luminance and reflectance of an image (Gonzalez and Woods, 1993). Thus it is possible to build a filter for each component separately, allowing us to control the contribution of each component on the image appearance. It is possible to separate the luminance from the reflectance component by applying the Neperian logarithm operator on the image:

$$\begin{aligned} f(x,y) &= i(x,y) \times r(x,y) \\ z(x,y) &= \ln(f(x,y)) \\ z(x,y) &= \ln(i(x,y)) + \ln(r(x,y)) \end{aligned}$$

Once the components are separated, the 2D Discrete Fourier Transform is computed. It is at this point that we can filter the image in the frequency domain:

$$\begin{aligned} \Im\left(z(x,y)\right) &= \Im\left(\ln(i(x,y))\right) + \Im\left(\ln(r(x,y))\right) \\ \Im\left(z'(x,y)\right) &= \Im\left(z(x,y)\right) \cdot \mathrm{H}(u,v) \end{aligned}$$

It will be necessary to perform the inverse process to obtain the filtered image in the spatial domain.

The low frequency components are associated with the illumination of the image and the high frequency ones with the reflectance of the image. So, to reduce the effects of changes in the illumination of the image, a high pass filter could be applied. We build this high pass filter from a low pass one in the next way:

$$\mathrm{H}'_{hp}(u,v) = 1 - \mathrm{H}_{lp}(u,v)$$
$$\mathrm{H}_{hp}(u,v) = (\alpha_h - \alpha_l) \cdot \mathrm{H}'_{hp}(u,v) + \alpha_l$$

Fig. 6(j) shows an example of image filtered with a homomorphic filter. This filter is expected to remove most of the variations due to lighting changes.

These are the main filters that students are encouraged to use and compare in this session. However, the tool implements some additional filters that the student can test optionally (Gaussian filter, Wiener filter, Average Filter and Laplacian filter). In all cases, the tool allows the student to fully configure the parameters of the filters. All the parameters must take value in a permitted interval that is show to the student.

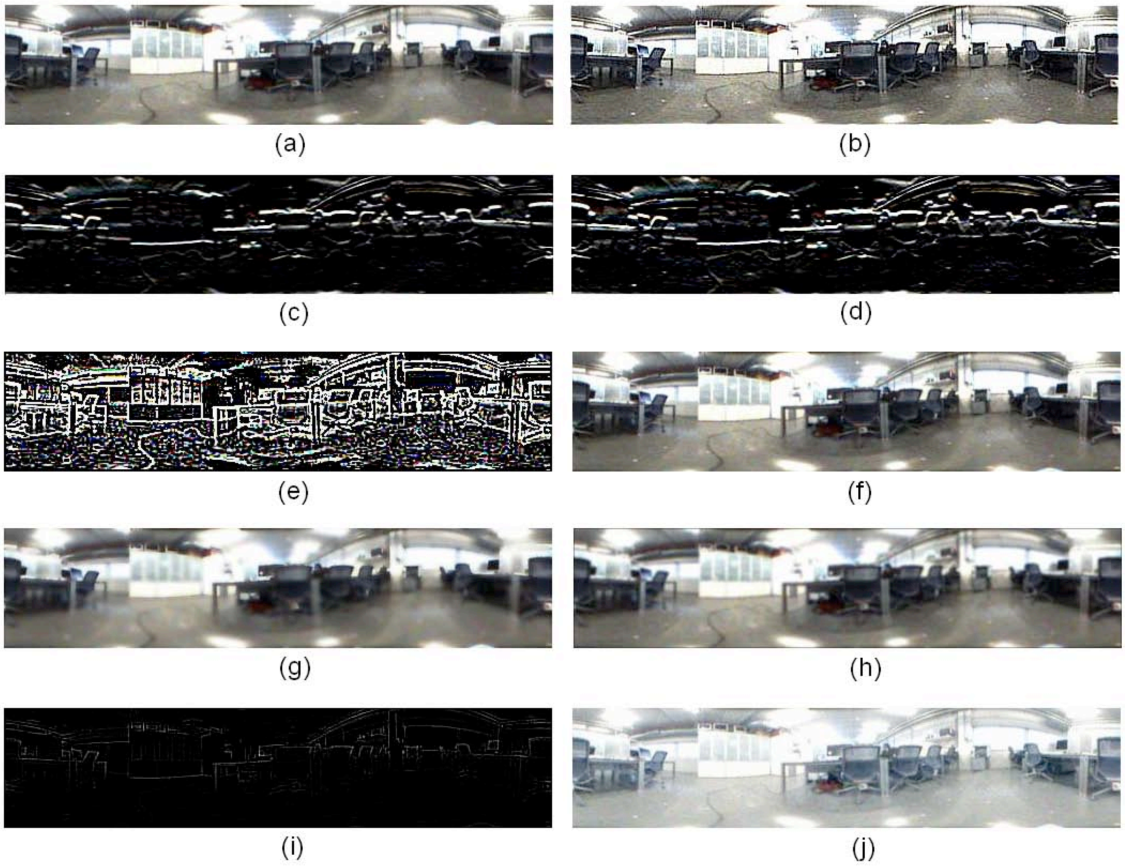

Figure 6. (a) Original colour image, and filtered image with (b) Unsharp, (c) Prewitt, (d) Sobel, (e) Laplacian of Gaussian, (f) Gaussian, (g) Wiener, (h) Average, (i) Laplacian and (j) Homomorphic filters.

To test the performance of these filters, several sets of test images are available in the interface. Fig. 7 shows one image per each set. There are 17 test images available in each test set.

4 CONCLUSION

In this paper we have presented the practical sessions we propose in a computer vision and robotics subject. We have implemented a software tool that acts as a guide to the student to facilitate the resolution of the proposed tasks, through a quite interactive and intuitive graphical interface. Thanks to this tool, the students can deepen in some of the basic concepts they study in the theoretical sessions, such as the colour representation of images, filtering processes, compression processes, etc. Besides, the tool allows them to face the typical problems that arise when building an application that includes computer vision in robotics, such as the lighting changes and the variability of the environment where the robot evolves.

This tool may also be used as a basis to develop more complex applications and so, its applicability may be easily extended. We are now developing a module that permits teleoperating the robot from the graphical interface of the tool. This new module opens the door to applications of online robot map building and localization, and extends the possibilities of the tool in a high degree.

We expect that this tool helps the students to fully understand the appearance-based approach in robotics mapping and other basic computer vision concepts and after using it, we expect they are able to design basic algorithms of visual robot mapping and localization.

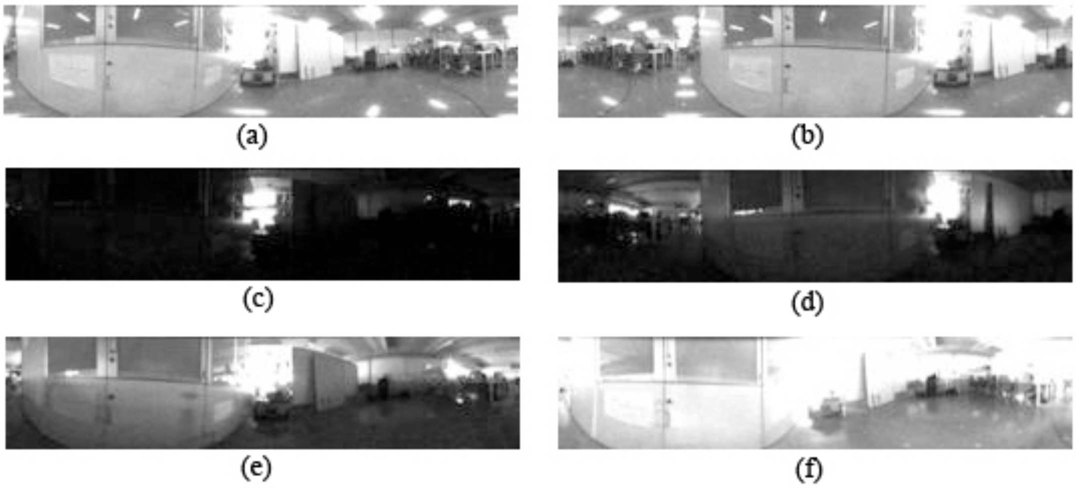

Figure 7: (a) Test 1 (9:00, artificial light), (b) Test 2 (9:00, artificial light, 90 degrees rotation), (c) Test 3 (18:00, no light), (d) Test 4 (11:00, natural light, 90 degrees rotation), (e) Test 5 (13:00, daylight) and (f) Test 6 (16:00, daylight).

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